Suisun Marsh geomorphologic process, ecosystem function, and contemporary management practice

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A Talk in Three Parts

with a gradient subplot

(and not enough time for the third part)

Take Home Message (1)

- **Recent historical land use practices (1850's to date) of diking, draining, farming, and seasonally managing Suisun Marsh tidal wetlands have altered or removed the geomorphologic processes which create and maintain Estuary tidal marsh landscapes**

Take Home Message (2)

- **Reduction of vascular plant primary productivity and reduced storage and/or oxidation of fixed organic carbon within Estuary tidal marshes has occurred coincidentally with a decline in Suisun Marsh/Estuary biological abundance, resilience, and diversity**

Geomorphology

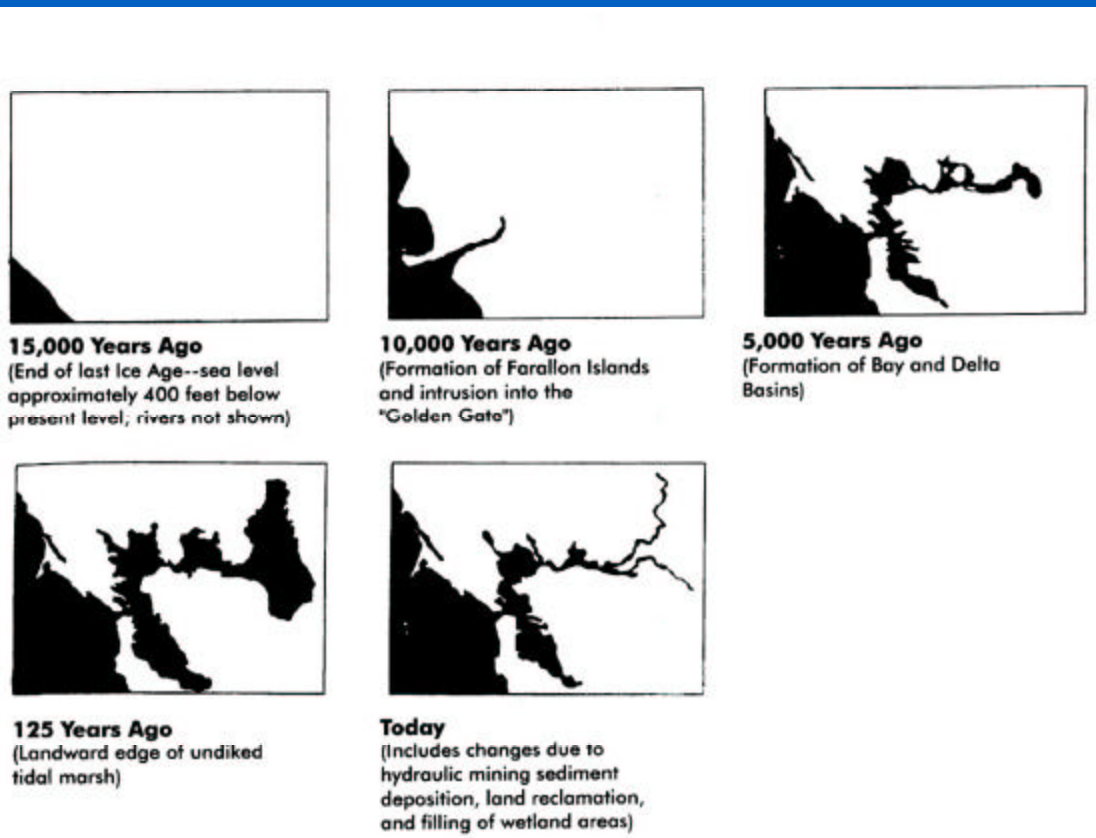
- **The study of landforms and the processes that make them**

Biogeomorphology

- **Geomorphology that considers the role of plants and animals in geomorphic processes**


WARNING
ALL CAMPFIRES PROHIBITED
ON GRIZZLY ISLAND ROAD
BEYOND THIS POINT
PEAT GROUND WILL BURN
SOLANO COUNTY ORD 875

SFE is a regressive estuary



Sequential sea level rise created the Bay-Delta we know today.
Source: San Francisco Estuary Project, adapted from Atwater 1979 and Atwater et al. 1979.

Bay Institute 1998

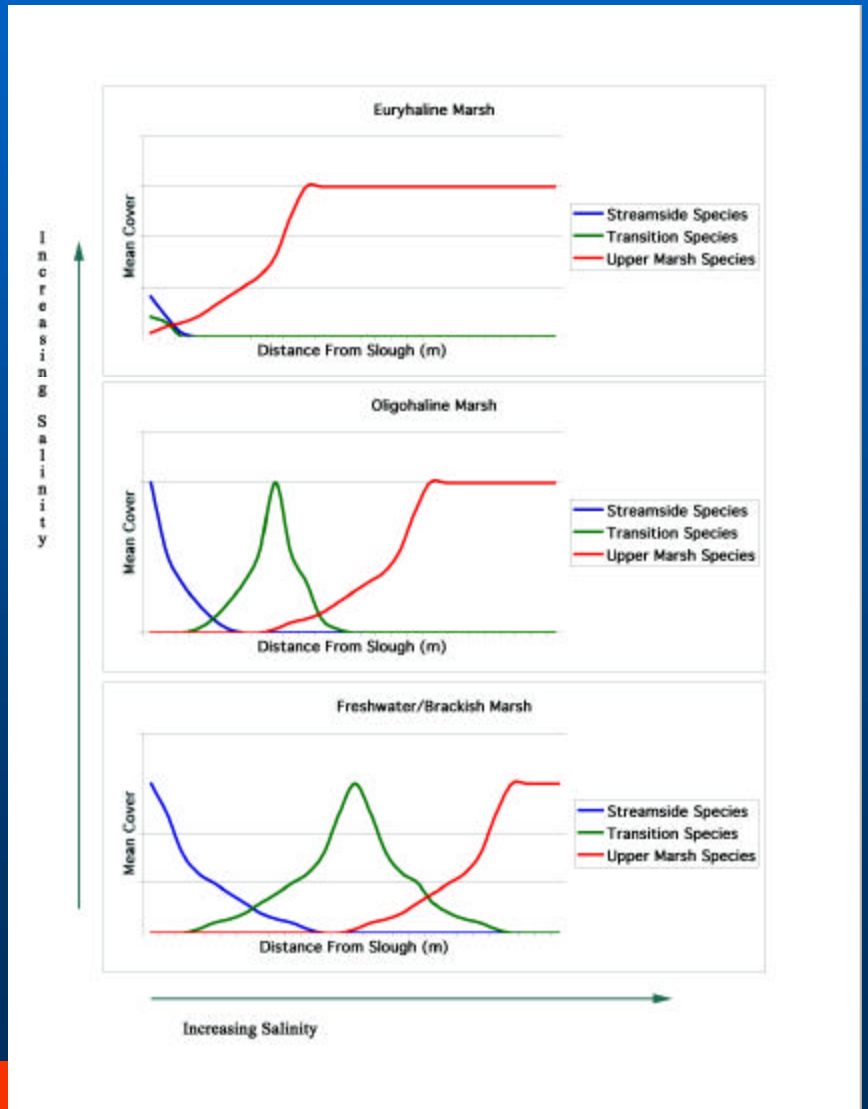
Supposition

- **Tidal marshes of the San Francisco Estuary occur at the interface of, and as the result of interactions between, a largely physical system (tides) and a largely biological system (vegetation distribution and productivity).**

Supposition Corollary

- **Physical system and biological system elements are necessary for the existence and maintenance of tidal marshes in the Estuary, and geographical gradients exist over which the strength of individual system elements vary.**

Example: Salinity Gradients and Plant Productivity



Culberson et al. 2004

Marsh Geomorphology – Tides, Accretion

Given:

Tides = *f* (ocean, sun, moon, meteorology, climate, land surface elevation)

Organic Matter accretion = *f* (source, transport, storage)

Marsh Geomorphology – Soils, Intertidal Elevations

Marsh Soils, Intertidal Elevations = *f* (Tides, Organic Matter Accumulation)

Evidence

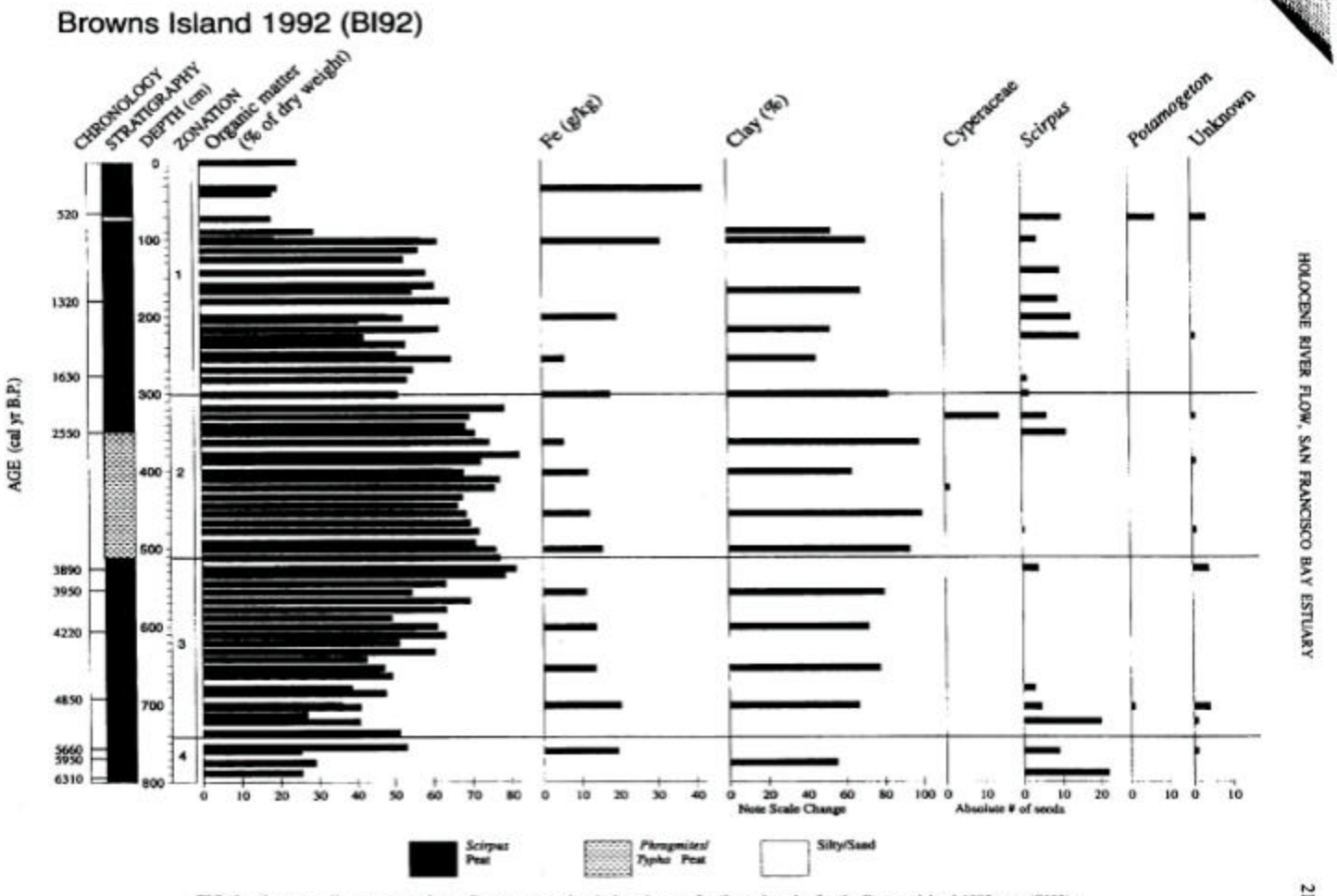


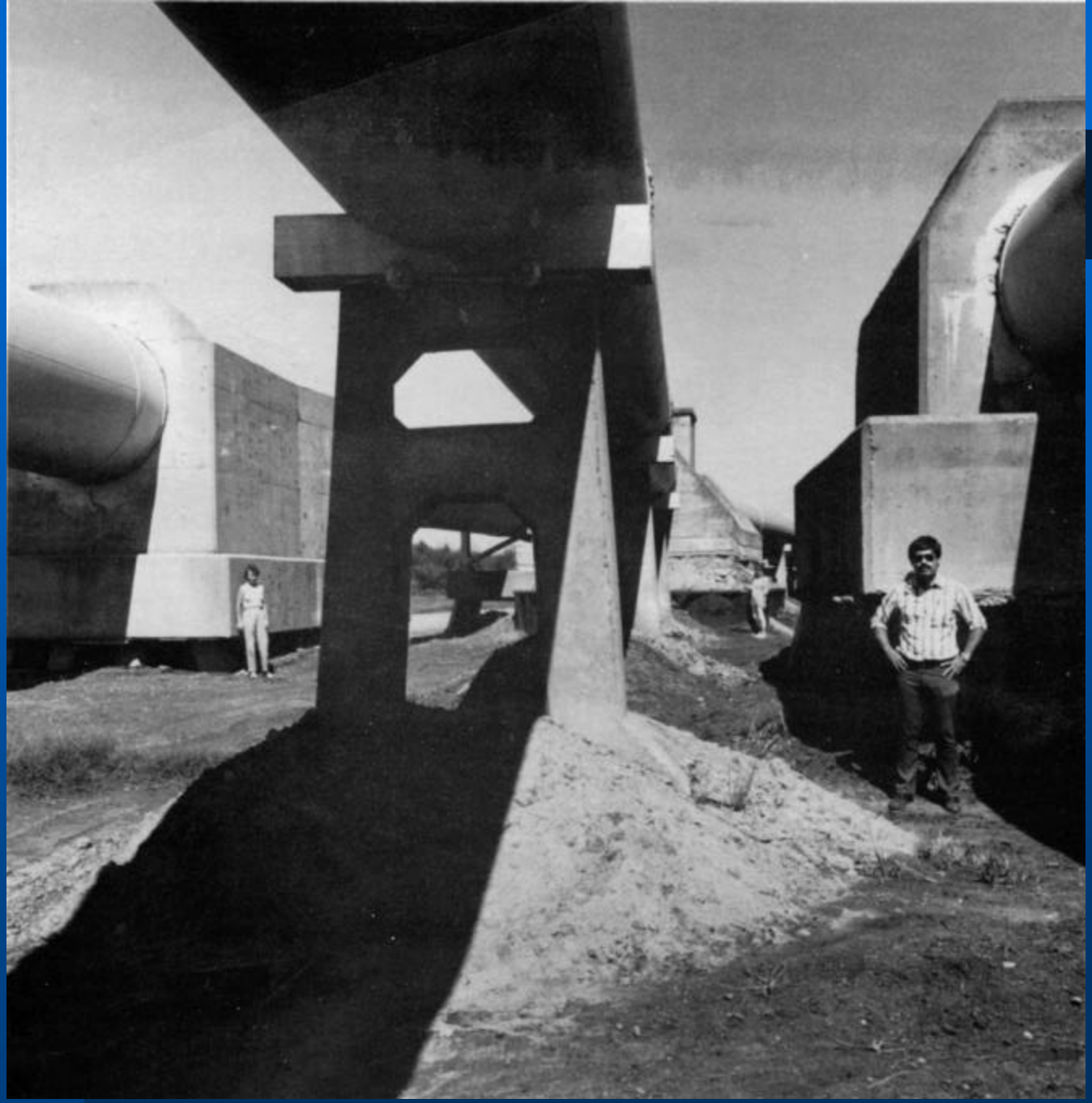
FIG. 3. Summary diagram presenting sedimentary, geochemical, and macrofossil stratigraphy for the Browns Island 1992 core (BI92).

Goman and Wells 2000

Marsh Geomorphology – Soils, Intertidal Elevations

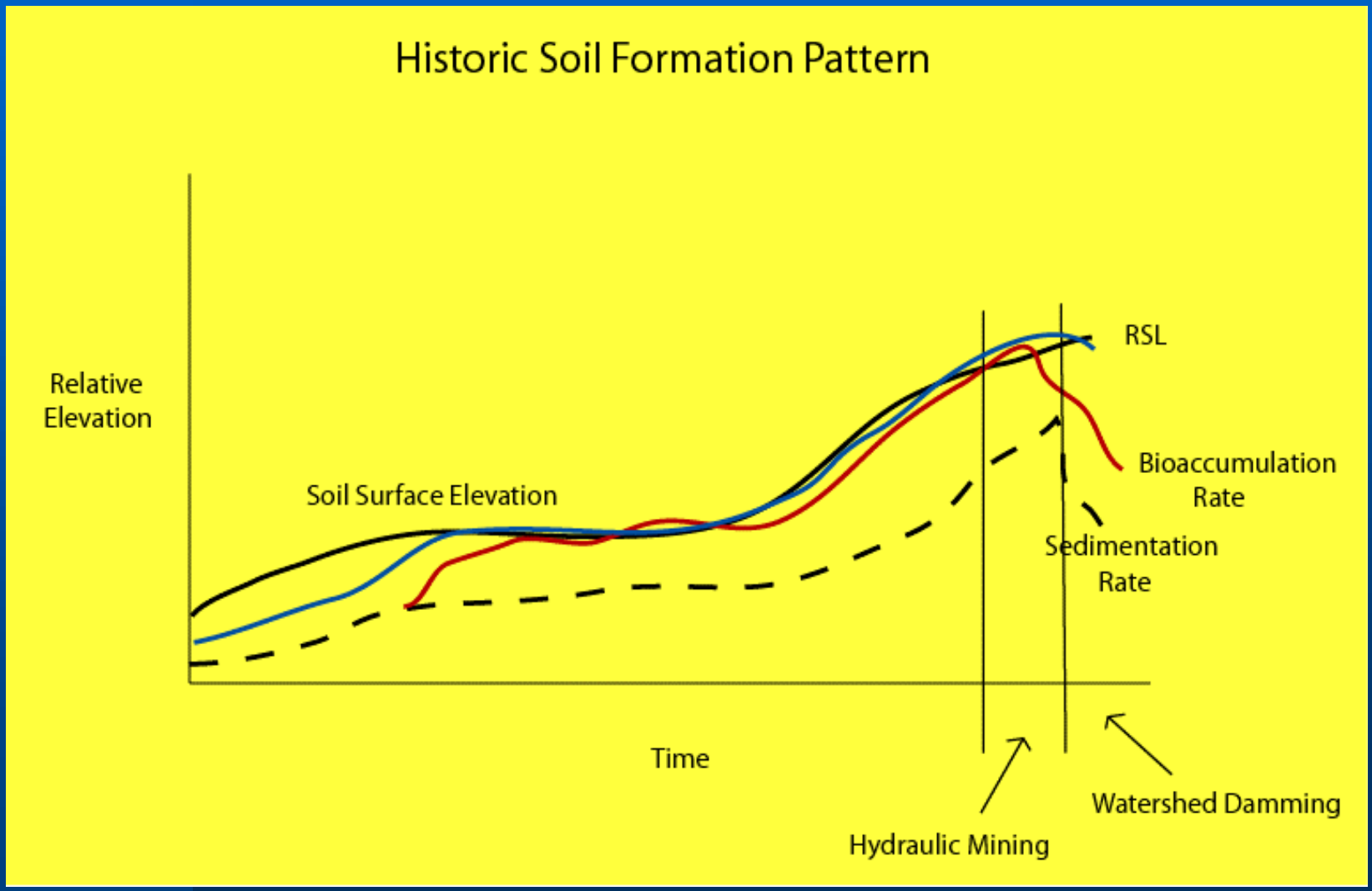
- **Removal of free tidal access alone has resulted in 1 – 3 feet of subsidence in Suisun Marsh**
- **Tilling, drying, burning of soils has resulted in additional subsidence in the Marsh and Delta**

DWR 2003



DWR 1987

Historic Processes



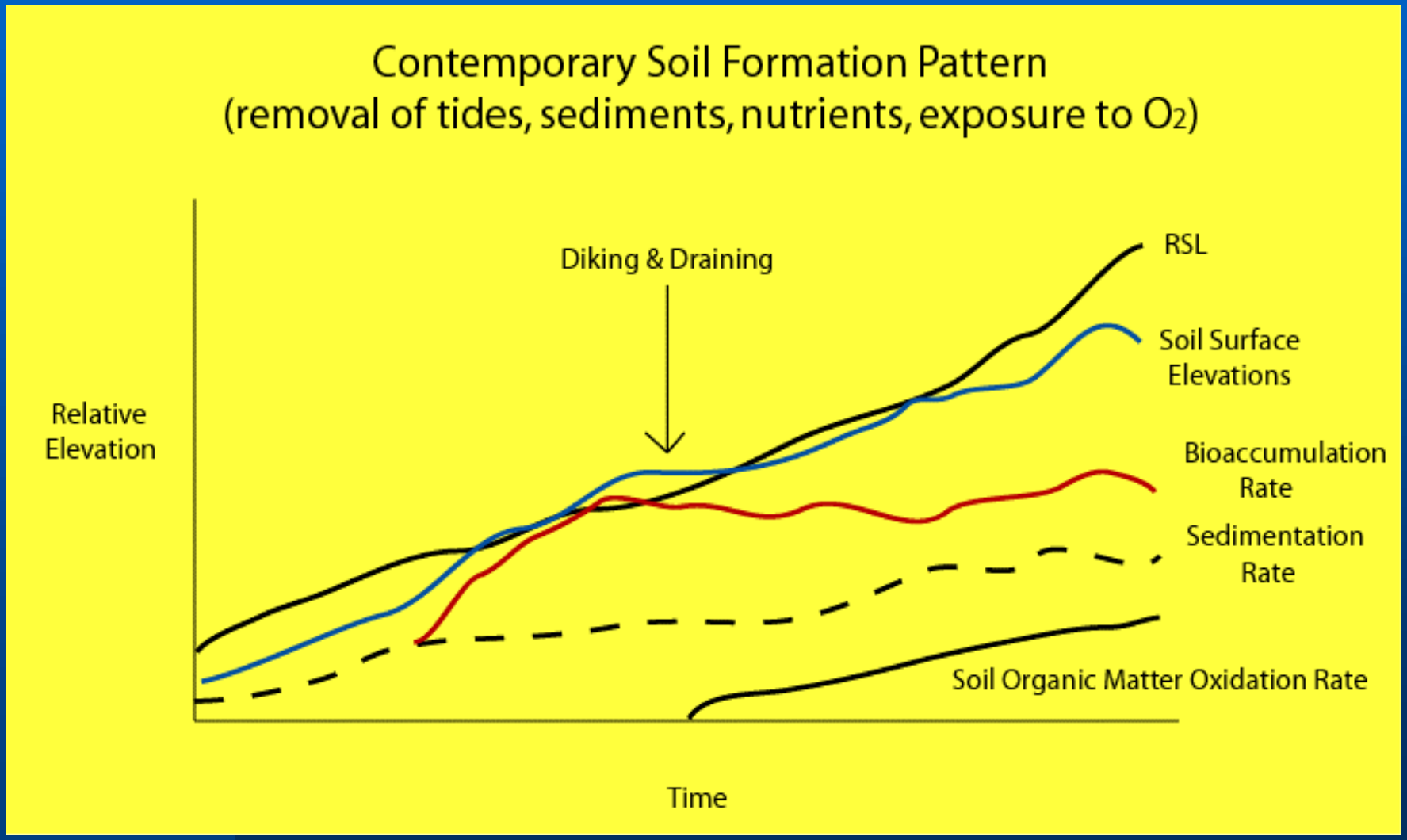
Contemporary Management Strategies

- **Maintain levee and water conveyance structures**
- **Maintain drainage and leaching capabilities**
- **Establish local brood ponds**
- **Maximize waterfowl-appropriate vegetation**
- **Annual maintenance and weed control**

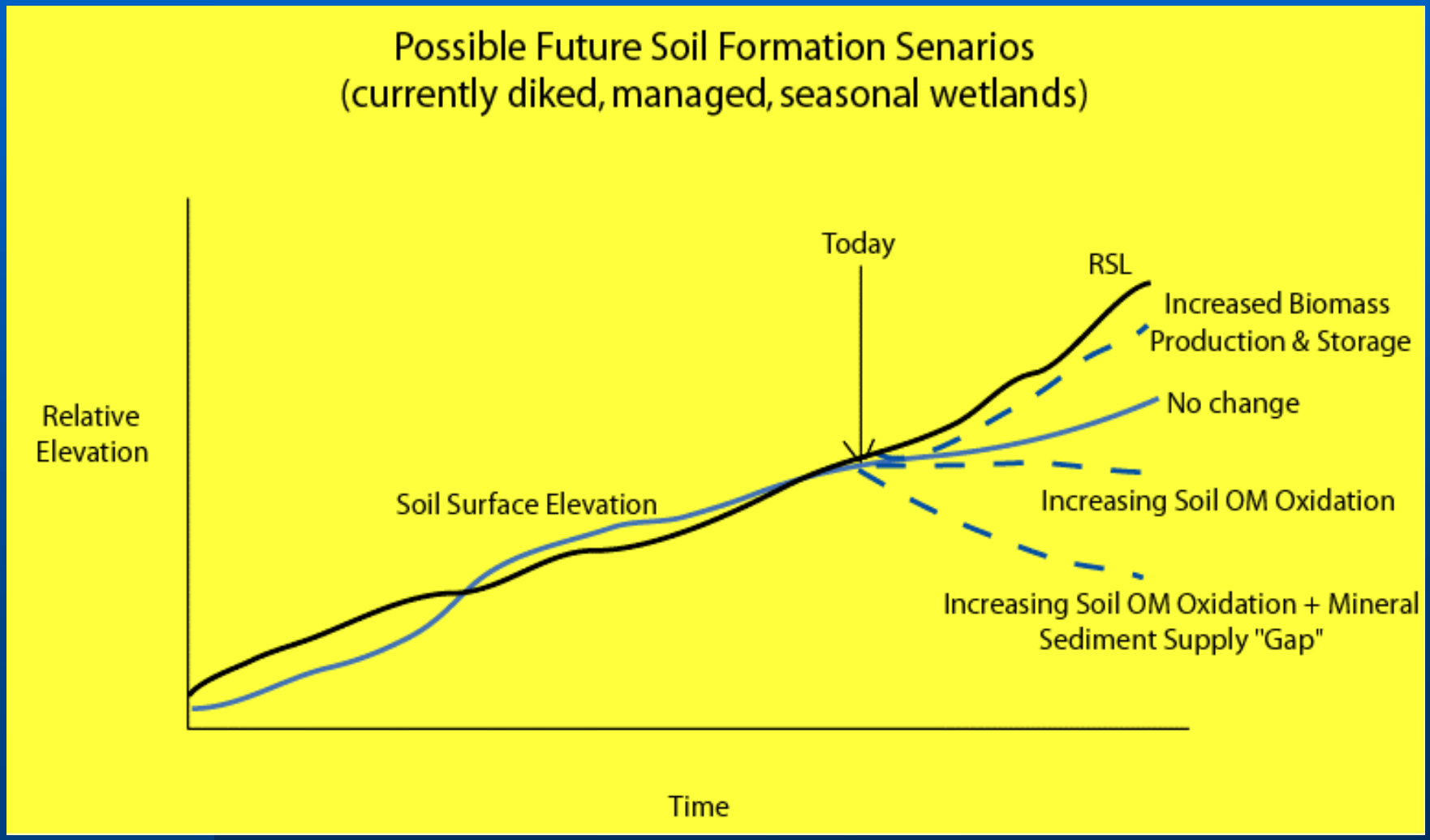
Consequences of Physical Manipulation/Management

- **Drying of surface soil horizons**
- **Oxidation of surface soil organic material**
- **Reduction of available soil pore water and plant productivity**
- **Local hypersalinity/acid leachates**
- **Attenuation of biomass/carbon production and storage**
- **Subsidence**

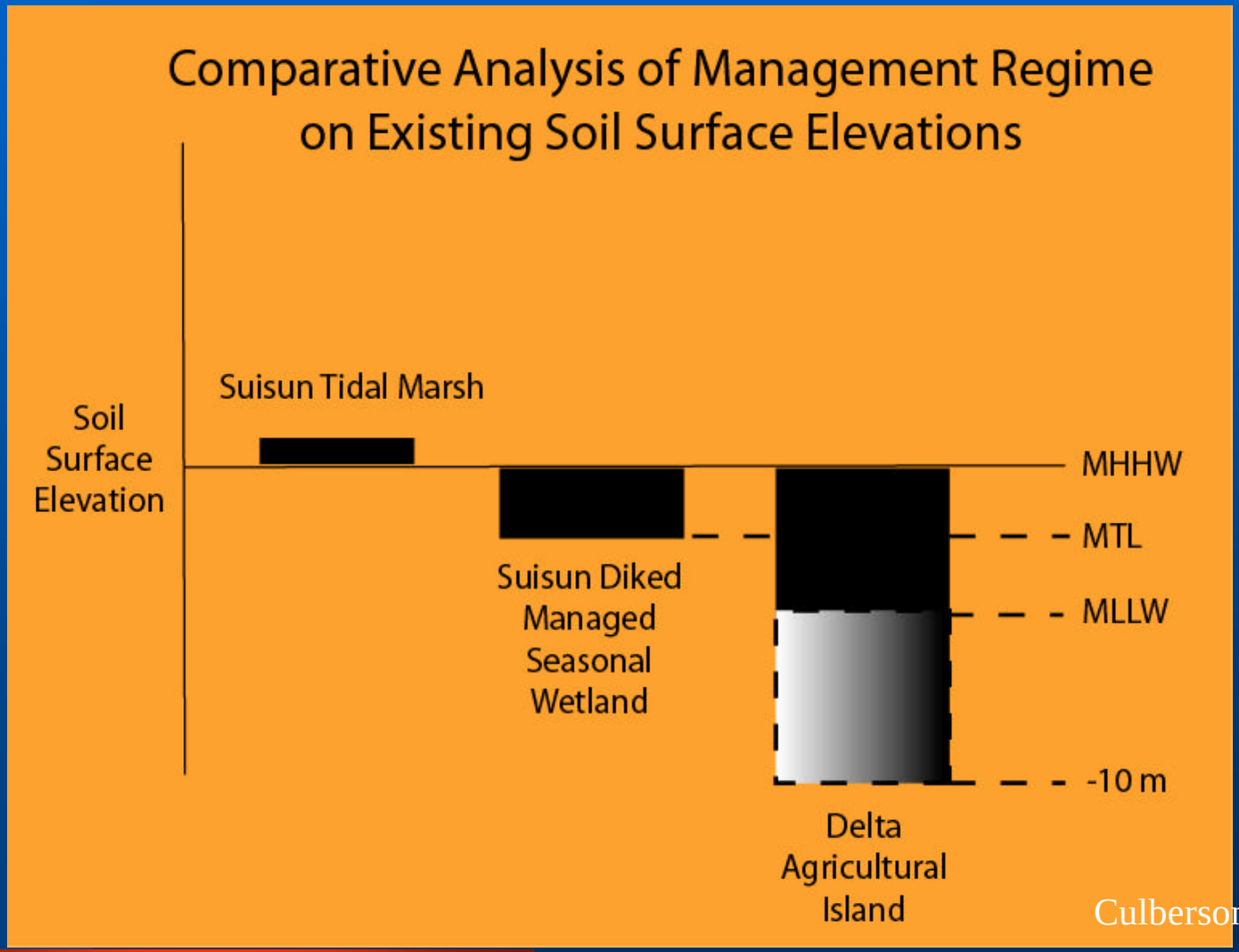
Present Processes



Future Process Trajectories?



Natural Experiment



Culberson, pers. obs.

Speculation

- **Is the loss of stored primary productivity in the form of sequestered plant biomass an element of Estuary biological productivity declines?**
- **Have we isolated Suisun (and Delta) ecosystem carbon cycling functions to the detriment of the regional ecosystem?**

"Tule breakers" – Bay Institute 1998

What if

- **We view the collapse of the ecological health of the Estuary as a change in the nature and quantity of organic carbon produced and stored system-wide?**

Management Directives

- ***Manage toward the natural template***
- ***Manage at ecosystem and landscape levels***

Biogeomorphologic Restoration

Maximize plant biomass productivity using vegetation communities adapted to ambient (historical) tidal regimes and salinities

Maximize *in situ* storage of organic matter and contributions to soil horizons

In other words

Let nature produce the carbon.

Let nature bury the carbon.

Leave the buried carbon alone.

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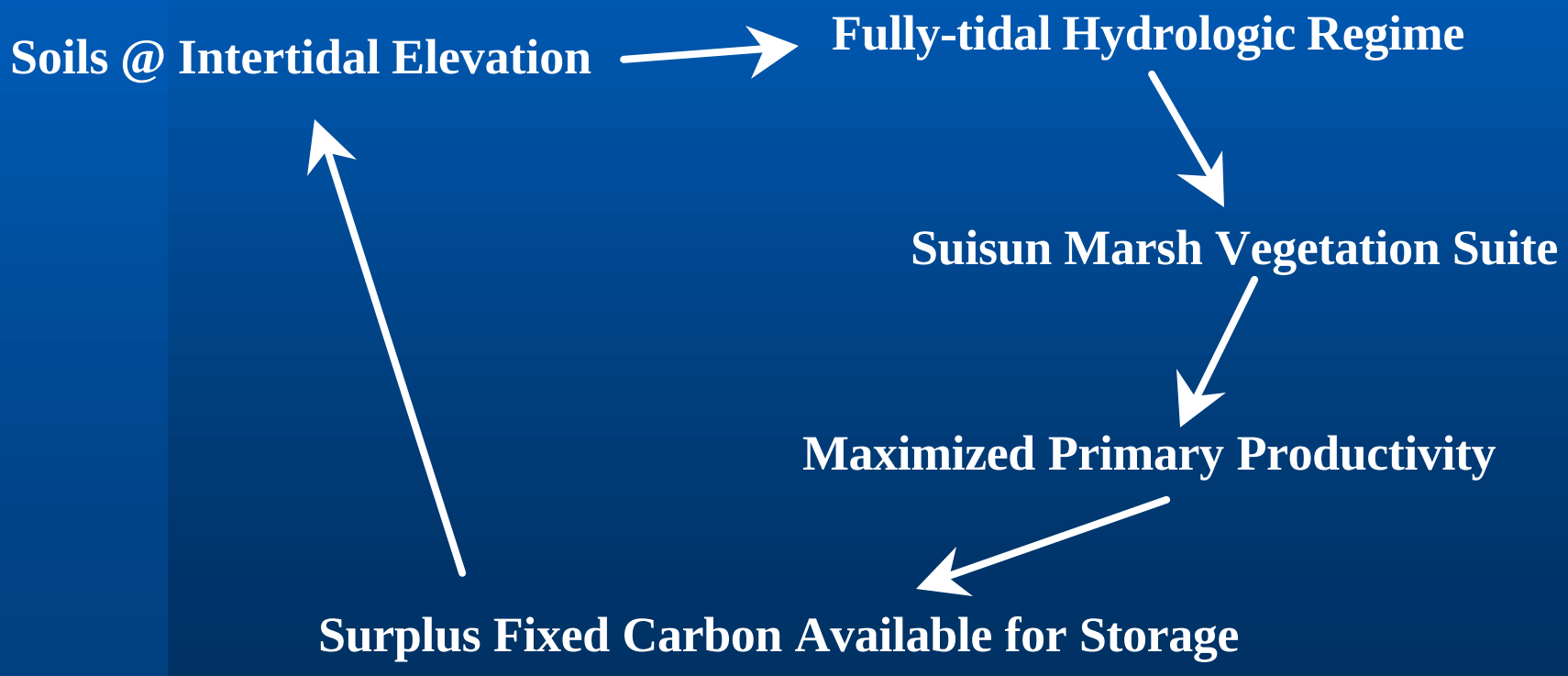
Intermission

Suisun Marsh Geomorphology: A Conceptual Model

- **Vegetation mediated carbon fixation and intertidal storage of local biomass – how environmental conditions and local productivity lead to *sustainable* tidal marsh soil elevations**

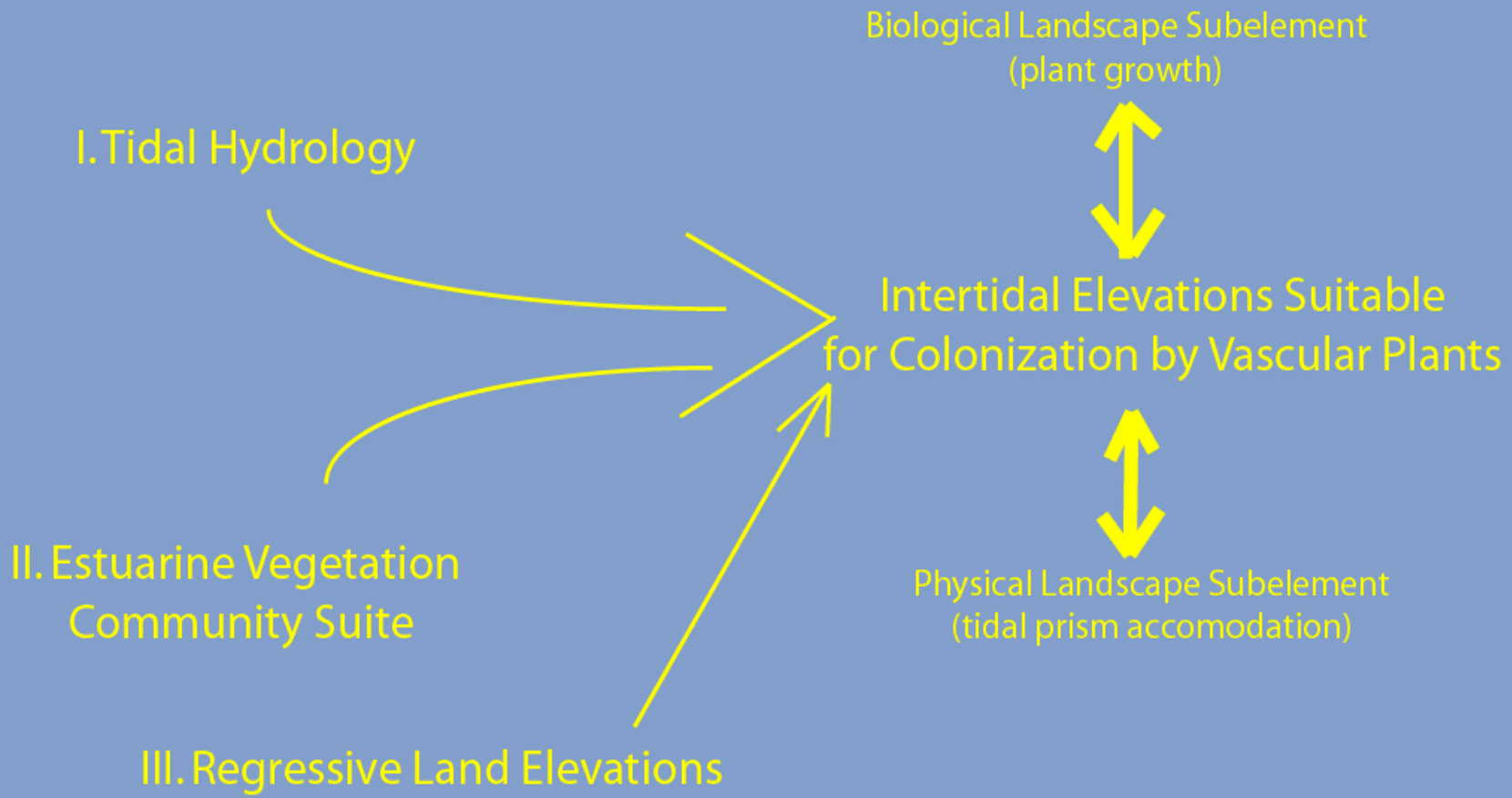
Conceptual View of Marsh as Carbon Storage Vessel



Conceptual Model of Suisun Marsh Geomorphology

Soils Forming and Sustaining Processes

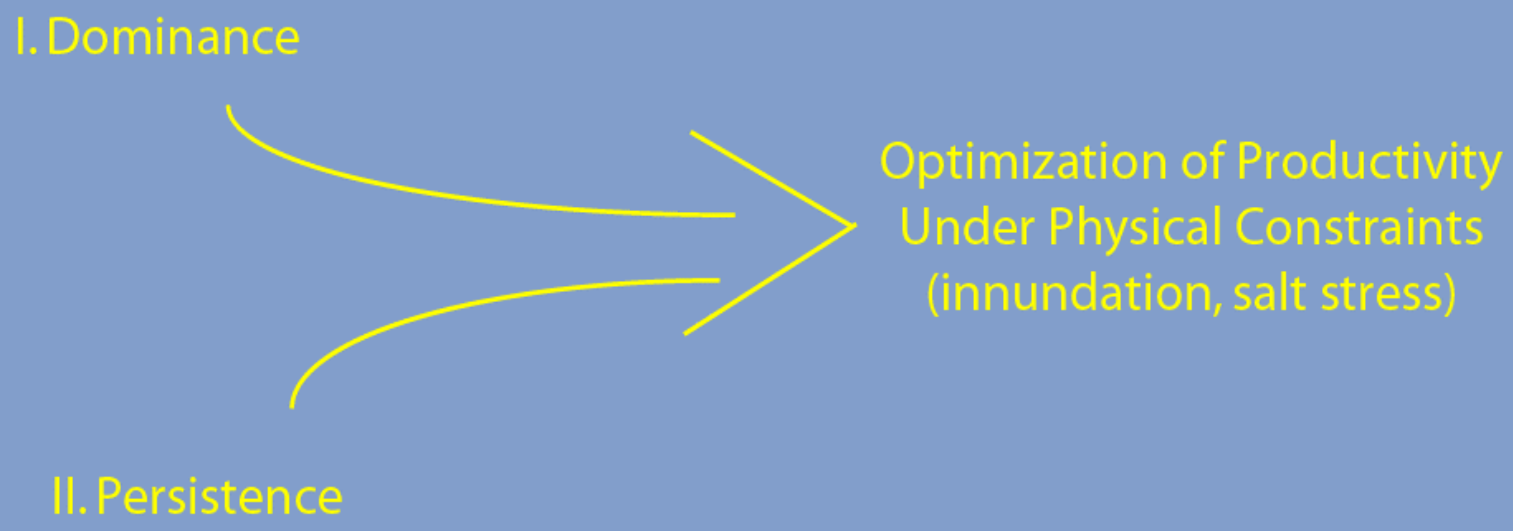
An Exercise in Complex Systems Organization



Conceptual Model of Suisun Marsh Geomorphology

Biological Systems Goal Seeking

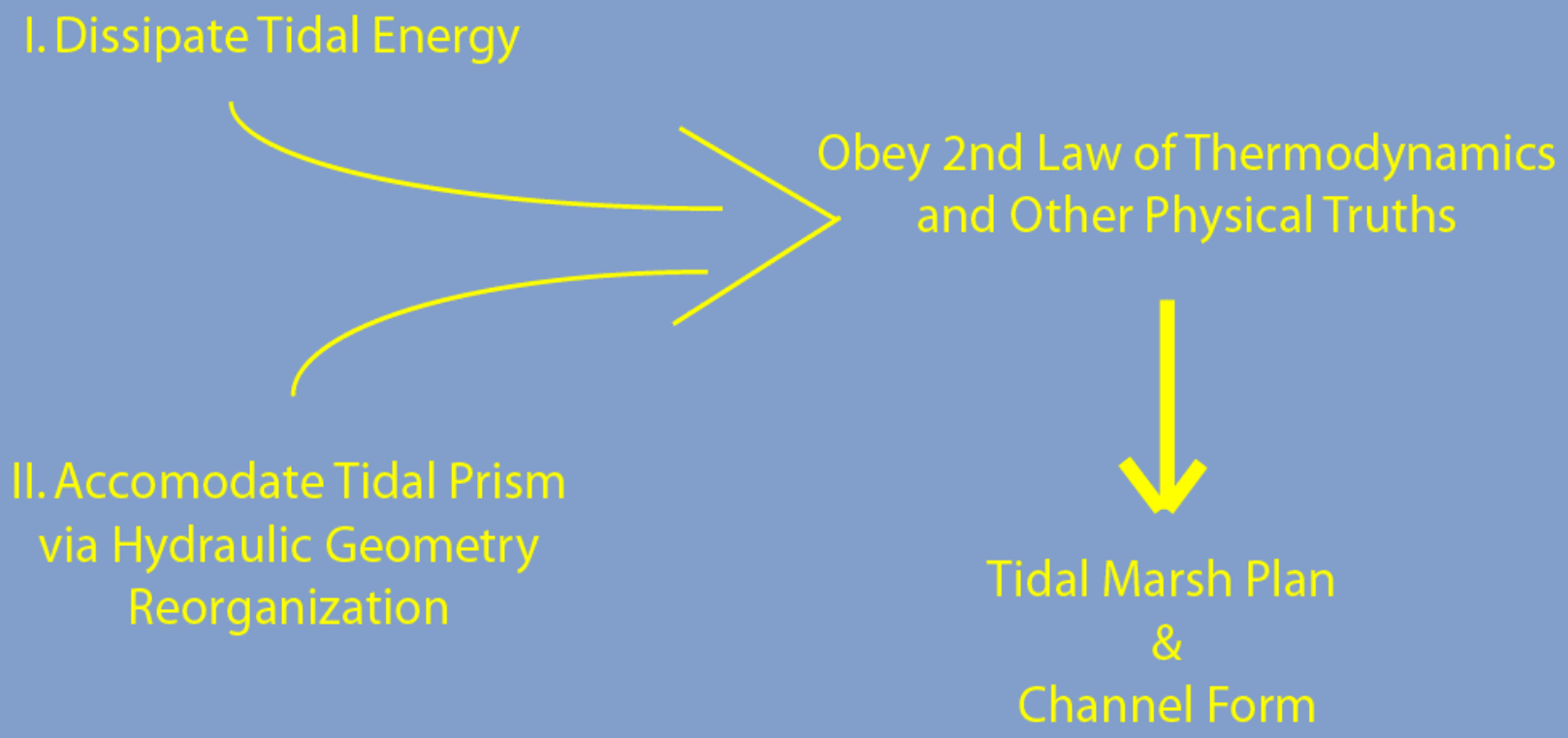
An Exercise in Complex Systems Organization



Conceptual Model of Suisun Marsh Geomorphology

Physical Systems Goal Seeking

An Exercise in Complex Systems Organization



Attributes

Conceptual Model of Suisun Marsh Geomorphology

Ecosystem/Biotic Landscape Subelement

An Exercise in Complex Systems Organization

I. Maximization of Primary Productivity and Incorporation of Surplus Biomass into Soil Horizons

II. Peat Creation and Trapping of Additional Allocthanous Materials

III. Marsh Ecosystem Ability to Track Changing RSL (Persistence) and Achieve Successful Genetic Transmission (Dominance)

IV. Native Vegetation Suite Includes Species Adapted to a Variety of Conditions and Can Therefore Tolerate, Thrive, and Persist Under Conditions of Flood, Drought, RSL Rise, Sediment Deposition, etc.

V. Peats Grow as High in the Intertidal Gradient as the Water Table Will Allow, Then Regress Until Upward Peat Building is Again Possible

Attributes

Conceptual Model of Suisun Marsh Geomorphology

Hydrologic Landscape Subelement

An Exercise in Complex Systems Organization

I. Dissipation of Tidal Energy & Accomodation of Tidal Prism (tidal volume)

II. If tidal energy or tidal volume diminish, tidal channel system "silts in"

III. If tidal energy or volume increase, tidal channel system "erodes"

IV. This leads to a dynamic equillibrium at the level of the tidal channel geometry

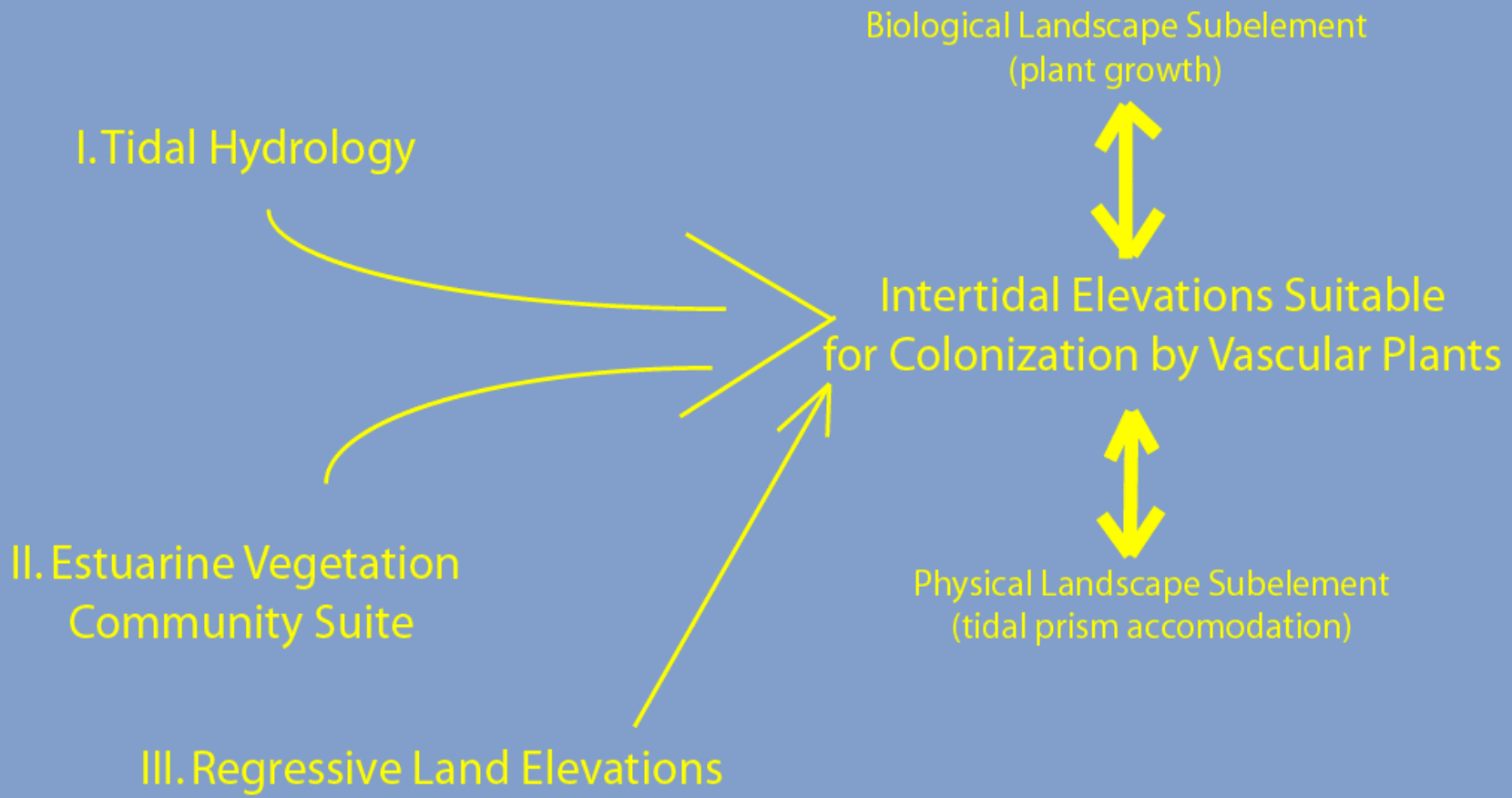
Linkage Between Landscape Elements

Vascular plants influence the "siltability" or "erodibility" of the tidal system, and themselves reflect the influence of other physical forcings (salinity, nutrients, etc.)

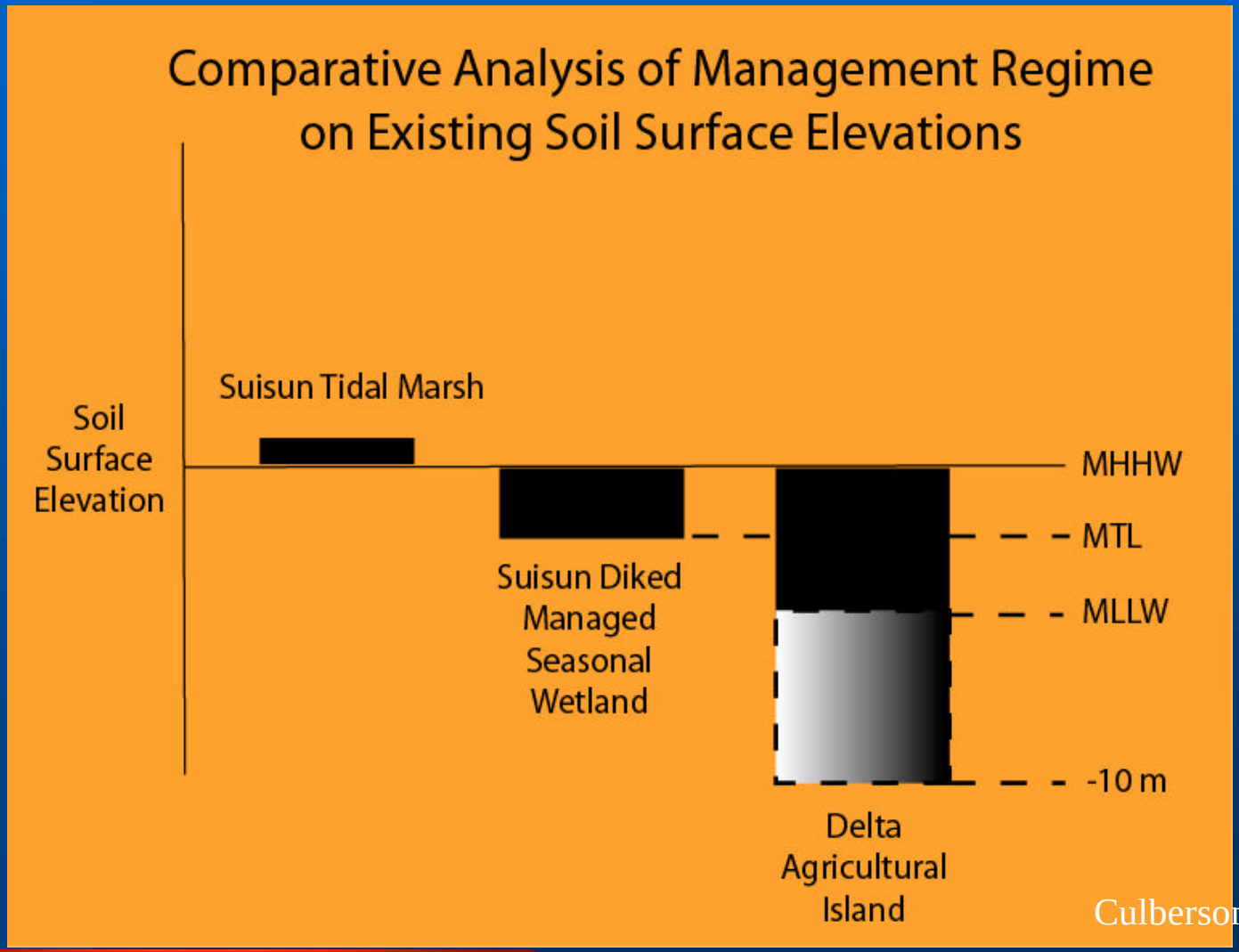
Conceptual Model of Suisun Marsh Geomorphology

Soils Forming and Sustaining Processes

An Exercise in Complex Systems Organization



Natural Experiment



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Additional Information Required

- **Comparative land use studies of soils characteristics, biogeochemical cycling, ecosystem functions**
- **Accurate, fine-scale elevation data describing Suisun Marsh intertidal elevations and soil surface directional tendencies**

Additional Research Topics

- **OM/Carbon production & storage rates**
- **Suisun-specific subsidence rates**
- **Regional rates of ground surface movement**
- **Local/regional groundwater characterization**

Implications from Carbon Storage Perspective

- **Near-aquatic terrestrial and near-terrestrial aquatic ecosystems closely coupled**
- **Nature of this coupling is intimate yet highly diffuse in natural systems**
- **Managed systems tend to decouple these systems and make the connections highly energetic and concentrated**


SUBJECT
TO FLOODING

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